# Use of DC-DC Converters at PP2

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## Advantages of approach

- Features of DC-DC converters
- Integration with cable plant
- Discussions with Modular Devices

# Advantages of MDI DC-DC Converters

- Provide full “transformer” isolation between input and output on both sides. Regulators only isolate the supply and not the return, so they do not break possible ground loops. This decouples “inside” and “outside” for noise/ground.
- Operate efficiently at large input voltage (e.g. 28V or 50V), allowing transmission of power to detector using smaller conductors. Power dissipation would be similar to that of regulators with 1V drop-out voltage (1W/A of dissipation).
- Because of full DC isolation, plus other features in the particular converter proposed by MDI, could consider the use of large bulk supplies in USA15. This would simplify the cable plant and reduce the USA15 power supply costs very significantly.
- Differential sensing is available, with no large currents in sense wires, and with the response tuned by MDI to our particular cable design.
- Units provide inhibit control and local current monitoring (available as a voltage proprotional to current). Also include overvoltage protection and current limiting. Input transient protection to 80V is provided, so units are very robust.
- Qualified to 200kRad and $10^{13}$ n/cm$^2$, which is a good match to cryostat endwall.
- Vendor burn-in cycle should guarantee MTBF of better than $5 \times 10^6$ hours.
- Constructed with Moly permalloy toroids instead of ferrite, so units will operate up to roughly 500 Gauss.


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# Proposal from MDI (Modular Devices, Inc)

- Located next to Brookhaven, so made a short visit in March after US Lehman review. Have supplied many space and military applications.
- Output would ramp to set point over period of about 1 second.
- Set point would be externally adjustable with a trim resistor.
- Output voltage range would be 1.6V to 2.5V with a current of 1.5A. Remote sense would be capable of recovering up to a 2V line drop.
- Large magnitude of line drop and large expected cable inductance would require measurement of cable parameters, reduction in loop bandwidth, and SPICE simulation of gain/phase to verify stability.
- Package size would be 1.5 cubic inches (roughly 25cc), and weight of about 65g.
- Cost estimate is $650 each, with 18K$ NRE and a 6 month development phase. Note at this power level, cost is essentially independent of power, so using one converter for two modules would halve the system cost.

# Proposal based on existing product 5680:

5680

28 VOLTS DC INPUT

Tech Specs
Pin Out Chart
Case Dimensions
Application Notes

PRINT PAGE

**12.5-30 Watt Hybrid**
**Proton Rad Hard DC-DC Converters**

Magnetically Isolated Series

Features:

- Proton Rad Hard
- SEU resistant
- Specifically designed for redundant or individual space applications
- Completely self contained Thick Film Hybrid DC-DC Converter
- No external filter caps required
- Fully isolated design
- "Inhibit-not" function
- Power on soft start
- 200 kHz operation for low ripple and fast response time
- Built-in EMI input filter meets MIL-STD-461C requirements CE01, CE03, CS01, CS02 and CS06
- Short circuit and overvoltage protection
- Capability of external synch for switching frequencies
- Built-in test capability

Specifications:

**INPUT:** 28 VDC nominal
Range: 16 to 50 VDC continuous
18 to 50 VDC full power
Survives 80 V transients/MIL-STD-704A

**ISOLATION:**
Input to case: 500 VDC
Input to output: 500 VDC
Output to case: 100 VDC

**ENVIRONMENT:**
Storage temperature: -55°C to +150°C
Shock: 50 G's
Acceleration: 500 G's
Vibration: 30 G's
Grades EU, RE & SE:
Full Power Output at Tcase = +125°C
Linearly derates to zero at Tcase = +135°C

**WEIGHT:** 75 grams typical
**PACKAGE and DIMENSIONS:** Many case styles are available. See package option chart.

# Low Voltage Power Cables:

## Preferred implementation:

- Electrically optimal option (assuming remote sensing at PP2), is broadside coupled strip lines. This is the only configuration capable of achieving low impedance and low inductance.
- However, if cables from individual modules are stacked, with no intervening shielding, then there is a low impedance, and a high capacitance, between the cables.
- Prefer to have a modest shielding layer between cables, but AC calculations needed to study its effectiveness.

## Example calculations:

- Compare twisted pair and “power tape” configurations.
- Twisted pair will always have an impedance close to 100-120Ω, a capacitance close to 40pF/m and an inductance close to 600nH/m.
- An ideal power tape with 1oz Cu (35μ) and 4mm wide traces with 75μ insulator between will have an impedance of about 4Ω, a capacitance of about 1200pF/m and an inductance of about 20nH/m. Thicker conductor and larger trace separation (cable thickness) will decrease the advantage of the power tape approach.

# PP2 Issues:

## Three different schemes possible:

- Baseline is long (140m) cables from USA15 with current sensing supplies.
- Second option is old PP2 location with possiblity to use power tapes for Type 1 and Type 2 cables (total of about 7m from module to PP2). In this case, either regulators or DC-DC converters could be used, since the gap is magnetically shielded to about the level needed. However, access is basically once per year.
- Third option is new PP2 location with possibility to use power tapes for Type 1 cables only (total of about 12m from module to PP2, with 9m of Type 2 cable). In this case, regulators could be used, but not DC-DC converters. Access could be weekly.

## Comparison of cables for latter two schemes:

- Old PP2 and power tapes: low impedance all of the way to Type 0, about 150nH of inductance and 8500pF of capacitance for isolated supply/return line.
- New PP2 and twisted pair: impedance of about 100Ω all of the way, about 7000nH of inductance and 500pF of capacitance. This is only somewhat modified by using power tape for Type 1, since it is a small fraction of the cable run.
- Result: roughly 50 times less inductance and 50 times more capacitance for power tapes and old PP2 location. Electrically, this would be strongly preferred, but high capacitance will also exist to adjacent tapes in service bundle.


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